17/3/2016
سكشن 3 ميكانيكا موائع
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Boundary layer theory

$$\delta^* = \delta_1 = \int_0^\delta \left(1 - \frac{u}{U}\right) dy.$$

$$\theta = \delta_2 = \int_0^\delta \frac{u}{U}\left(1 - \frac{u}{U}\right) dy.$$

$$\delta_e = \delta_3 = \int_0^\delta \frac{u}{U}\left(1 - \left(\frac{u}{U}\right)^2\right) dy$$

sheet. 1   No. 3 $\frac{u}{U} = \left(\frac{y}{\delta}\right)^{1/7}$

Calculate

a) δ_1

b) δ_2

c) shape Factor $= \frac{\delta_1}{\delta_2}$

d) δ_3

e) → $\delta = 25$ mm, $U = 15$ m/s, $Q = 6$ m/s, $\rho = 1.2$ kg/m^3

Find E_{loss} =?!

Solution

$$\delta_1 = \int_0^\delta \left(1 - \frac{u}{U}\right) dy = \int_0^\delta \left[1 - \frac{y^{1/7}}{\delta^{1/7}}\right] dy$$

$$= \left[y - \frac{y^{8/7}}{8/7 \cdot \delta^{1/7}}\right]_0^\delta = \left[\delta - \frac{\delta^{8/7}}{8/7 \cdot \delta^{1/7}}\right] = \left[\delta - \frac{7}{8}\frac{\delta^{8/7}}{\delta^{1/7}}\right]$$

$$= \left[\delta - \frac{1}{8}\delta\right] = \left[1 - \frac{7}{8}\right]\delta = \frac{1}{8}\delta.$$

b)

$$\delta_2 = \int_0^\delta \frac{u}{U}\left(1-\frac{u}{U}\right)dy = \int_0^\delta \left(\frac{u}{U} - \left(\frac{u}{U}\right)^2\right) dy.$$

$$= \int_0^\delta \left[\frac{y^{1/7}}{\delta^{1/7}} - \frac{y^{2/7}}{\delta^{2/7}}\right]dy$$

$$= \frac{7}{8}\frac{\delta^{8/7}}{\delta^{1/7}} - \frac{7}{9}\frac{\delta^{9/7}}{\delta^{2/7}} = \frac{7}{8}\delta - \frac{7}{9}\delta.$$

$$\delta_2 = \frac{7}{72}\delta$$

shape Factor $= \frac{\delta_1}{\delta_2} = \checkmark\checkmark$

$$\delta_3 = \int_0^\delta \frac{u}{U}\left[1-\left(\frac{u}{U}\right)^2\right]dy$$

$$= \int_0^\delta \left[\frac{u}{U} - \left(\frac{u}{U}\right)^3\right]dy$$

$$= \int_0^\delta \left[\frac{y^{1/7}}{\delta^{1/7}} - \frac{y^{3/7}}{\delta^{3/7}}\right]dy$$

$$= \frac{7}{8}\frac{\delta^{8/7}}{\delta^{1/7}} - \frac{7}{10} * \frac{\delta^{10/7}}{\delta^{3/7}} = \frac{7}{8}\delta - \frac{7}{10}\delta.$$

$$\boxed{\delta_3 = \frac{7}{40}\delta}$$

c

$$E_L = \frac{1}{2}\left[\rho * \delta_3 * 1 * U\right] * U^3$$

$$= \frac{1}{2} * 1.2 * \frac{7}{40} * \frac{25}{100} * [15]^3 = \checkmark\checkmark \quad J/s$$

E_L Hydrolic power $= \Delta P\, Q = \rho g H_L Q$

$$E_L = \underbrace{\rho g h_L}_{\Delta P} Q = \checkmark\checkmark$$

$$\therefore h_L = \checkmark\checkmark \ m$$

No. 4 $\quad \frac{u}{U} = \left(\frac{y}{\delta}\right)^{0.22}$

$U = 20\ m/s \qquad Q = 5\ m^3/s$

$\delta = 5\ cm$

calculate [a] δ_1 [b] δ_3 [c] E_L

Solution

$$\delta_1 = \int_0^\delta \left(1 - \frac{u}{U}\right) dy = \int_0^\delta \left(1 - \left(\frac{y}{\delta}\right)^{0.22}\right) dy = \left[\delta - \frac{1}{1.22} \frac{\delta^{1.22}}{\delta^{0.22}}\right.$$

$$\delta_1 = \delta - \frac{1}{1.22}\delta = ___\ \delta$$

d)

$$\delta_3 = \int_0^\delta \frac{u}{U}\left[1-\left(\frac{u}{U}\right)^2\right]dy.$$

$$= \int_0^\delta \left[\frac{u}{U} - \left(\frac{u}{U}\right)^3\right] dy = \int_0^\delta \left[\frac{y^{0.22}}{\delta^{0.22}} - \frac{y^{0.66}}{\delta^{0.66}}\right] dy.$$

$$= \left[\frac{1}{1.22}\frac{\delta^{1.22}}{\delta^{0.22}} - \frac{1}{1.66}\frac{\delta^{1.66}}{\delta^{0.66}}\right]$$

$$\delta_3 = \frac{1}{1.22}\delta - \frac{1}{1.66}\delta = \text{---}\ \delta$$

$$E_L = 1/2\left[\rho * \delta_3 * 1 * U\right] U^2$$

$$= 1/2\left[1000 * \boxed{//} * \frac{5}{1000} * (20)^3\right.$$

$$E_L = \text{--}\ J/s$$

No. 5 $\quad \dfrac{u}{U} = \left(\dfrac{y}{\delta}\right)^{0.22}$

$U = 30\ m/s$

$\delta = 60\ mm$

$Q = 6\ m^3/s$

calculate

[a] $\delta_1 = ??$

[b] δ_3

[c] $E_L = ??$

[4] نفس مسألة

Von Karman momentum equation

$$\boxed{\frac{\tau_o}{\rho U^2} = \frac{c_f}{2} = \frac{d\delta_2}{dx} = \frac{d\theta}{dx}}$$

velocity profiles

ch2

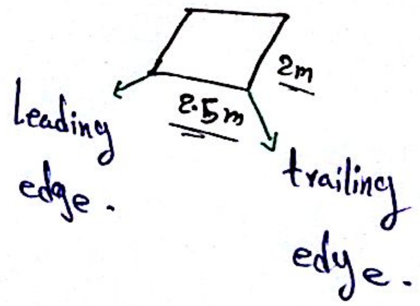
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sheet [1] **No. [6]**

$S.G_{oil} = 0.8$

$U = 1.5\ m/s$, $\nu = 10^{-4}\ m^2/s$

Find [1] δ [2] τ_o



solution

$$Re = \frac{\rho V x}{\mu} = \frac{V x}{\nu} = \frac{1.5 * 2.5}{10^{-4}} = 37500 < 3.2 * 10^5$$

تحقق معادلة : Blasius Formula.

F

$$\delta_L = \frac{5L}{\sqrt{Re_L}} = \frac{5 * 2.5}{\sqrt{37500}}$$

$$\therefore \delta = \surd\surd$$

$$C_{f_L} = \frac{0.664}{\sqrt{Re_L}} = \surd\surd$$

$$\therefore \frac{\tau_0}{\rho U^2} = \frac{C_f}{2}$$

$E_{\infty} \leftarrow$

$$\tau_0 = \surd\surd$$